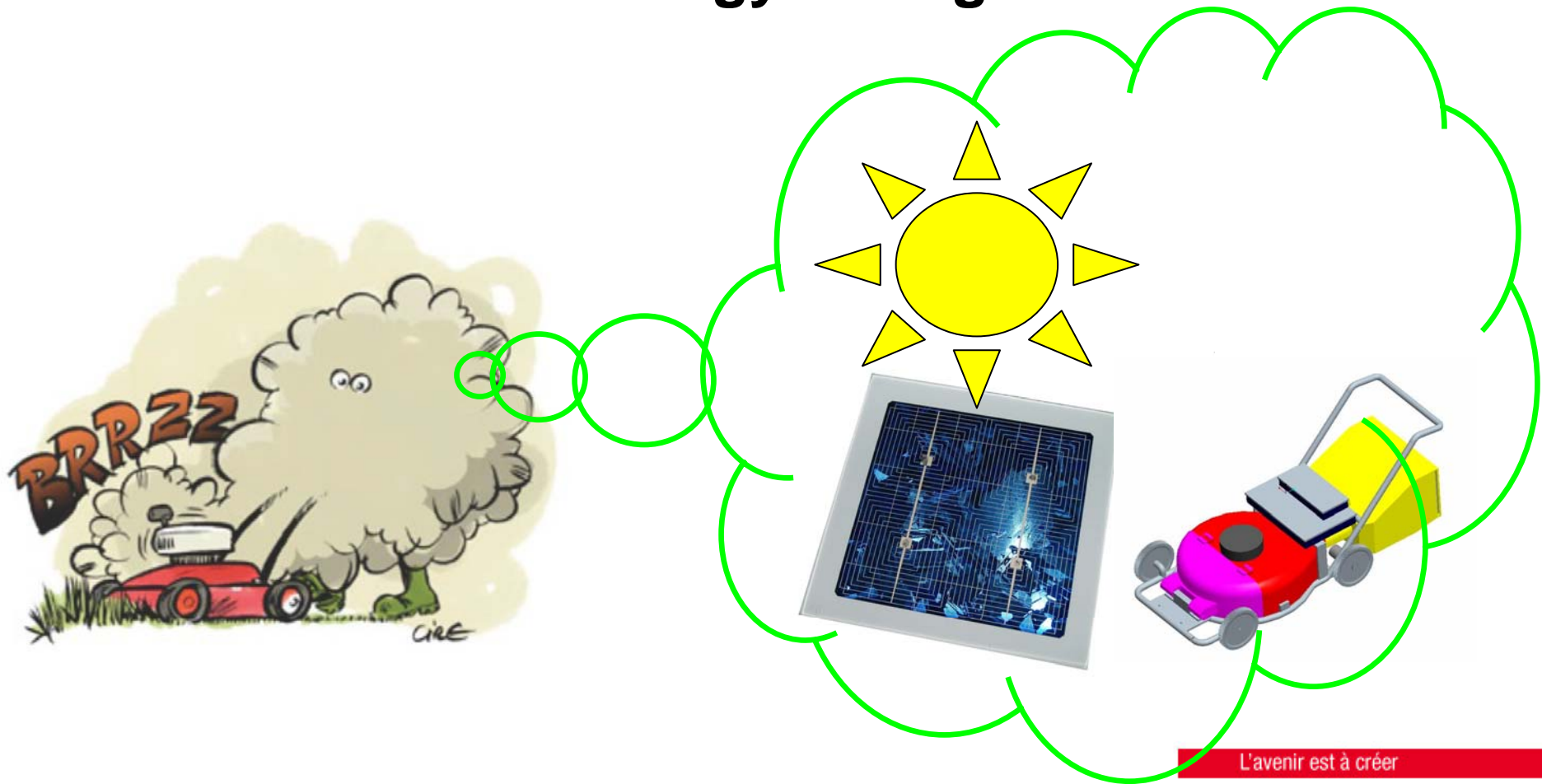


What can be learned by an exercise of eco design of solar lawn mower?

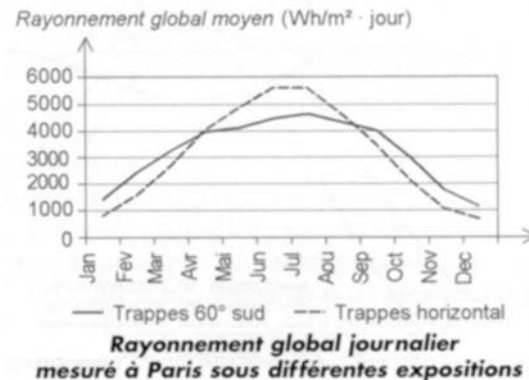
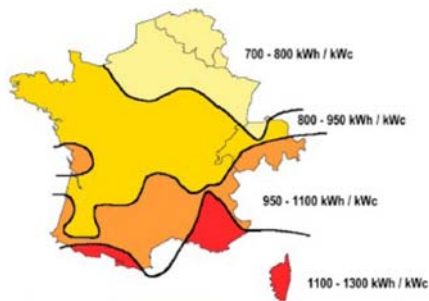
Questions about energy storage with batteries.



Solar lawn mower specifications

The basic idea of this lawn mower using 100% renewable energy was, for typical private consumer.

- mow 1000 – 1500 m² lawn ~ once a week
- 4 KW
- Self towed

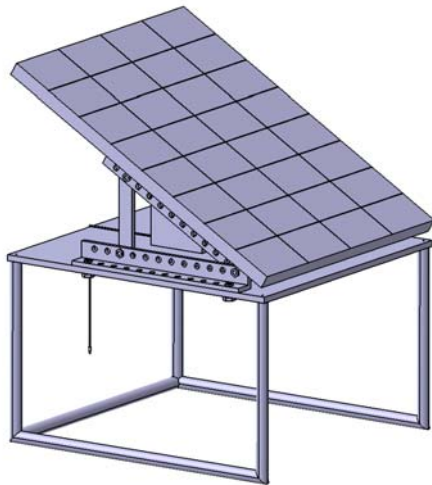


Lawn growth rate is well correlated to solar energy input

=> It is needed to mow the lawn 16-20 times in a year from April to October

Solar lawn mower concept:

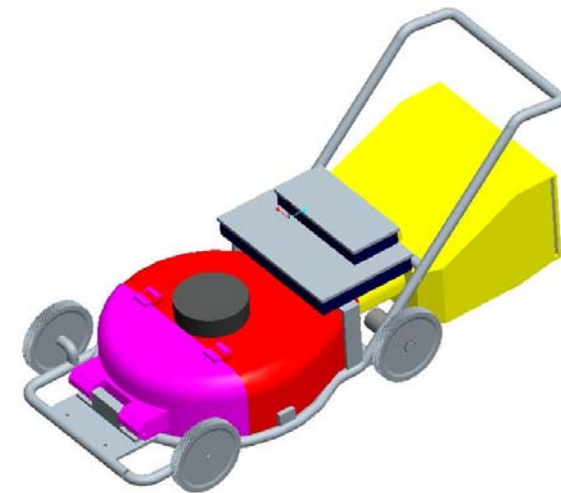
1.5 m² photovoltaic cell (multi-Si)



15 kg Li-Io batteries



General assembly



Eco design exercise

Student: Gizem CAN, Jérémy GRANDJEAN, Victor NGUYEN, Maxime PRAZ, Pedro SANCHEZ, Sylvain TOZZINI

Solar lawn mower comparative LCA :

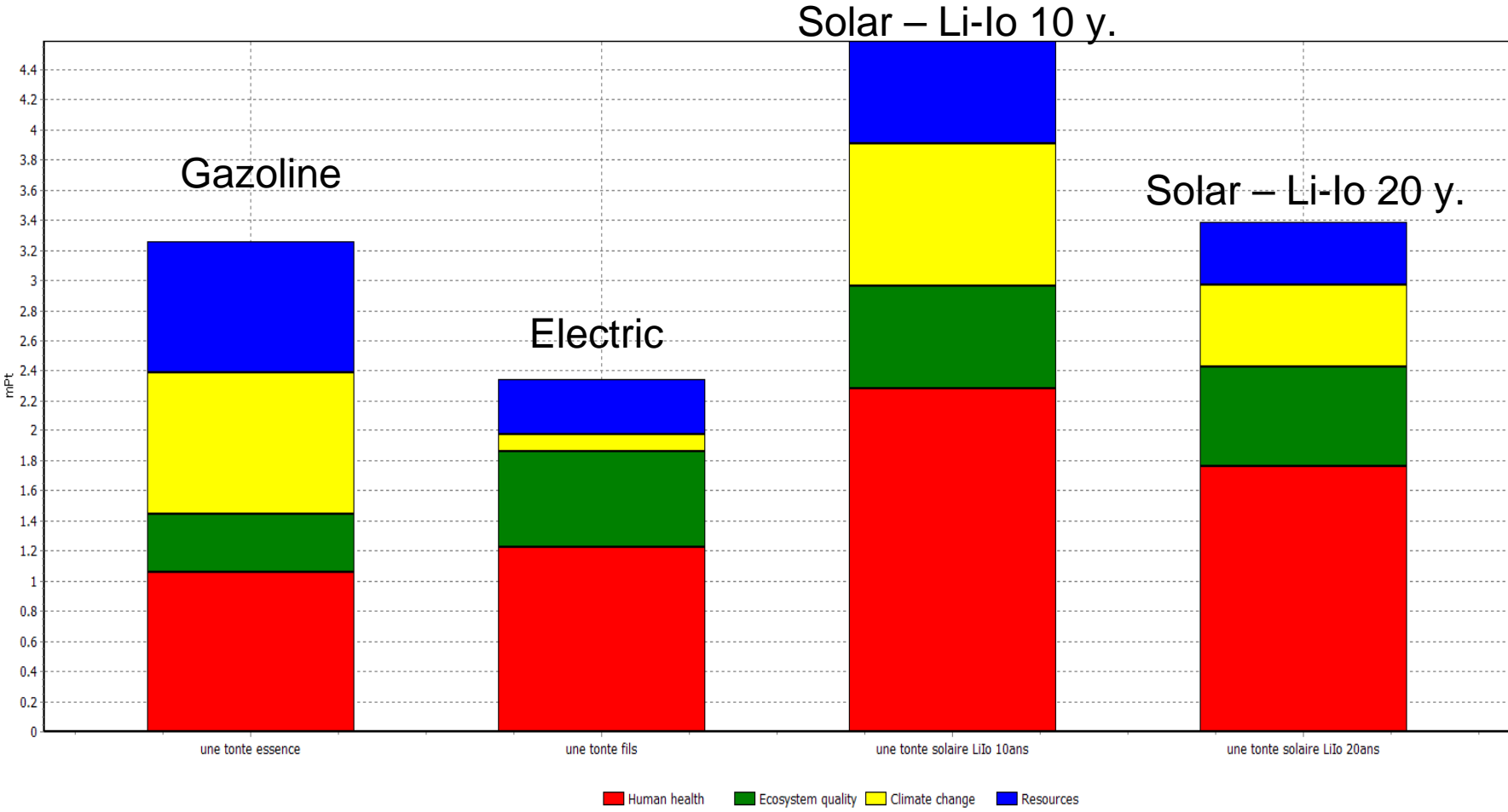
Scenarios considered for comparison:

- Gasoline lawn mower (~ 3 l / lawn mow)
- Electric lawn mower (6.75 kWh CH electricity)
- Solar lawn mower
 - Li-Io batteries 10 years longevity
 - Li-Io batteries 20 years longevity

LCA model with:

SIMAPRO / Data from ECOINVENT + USA input-output database /
IMPACT2002+

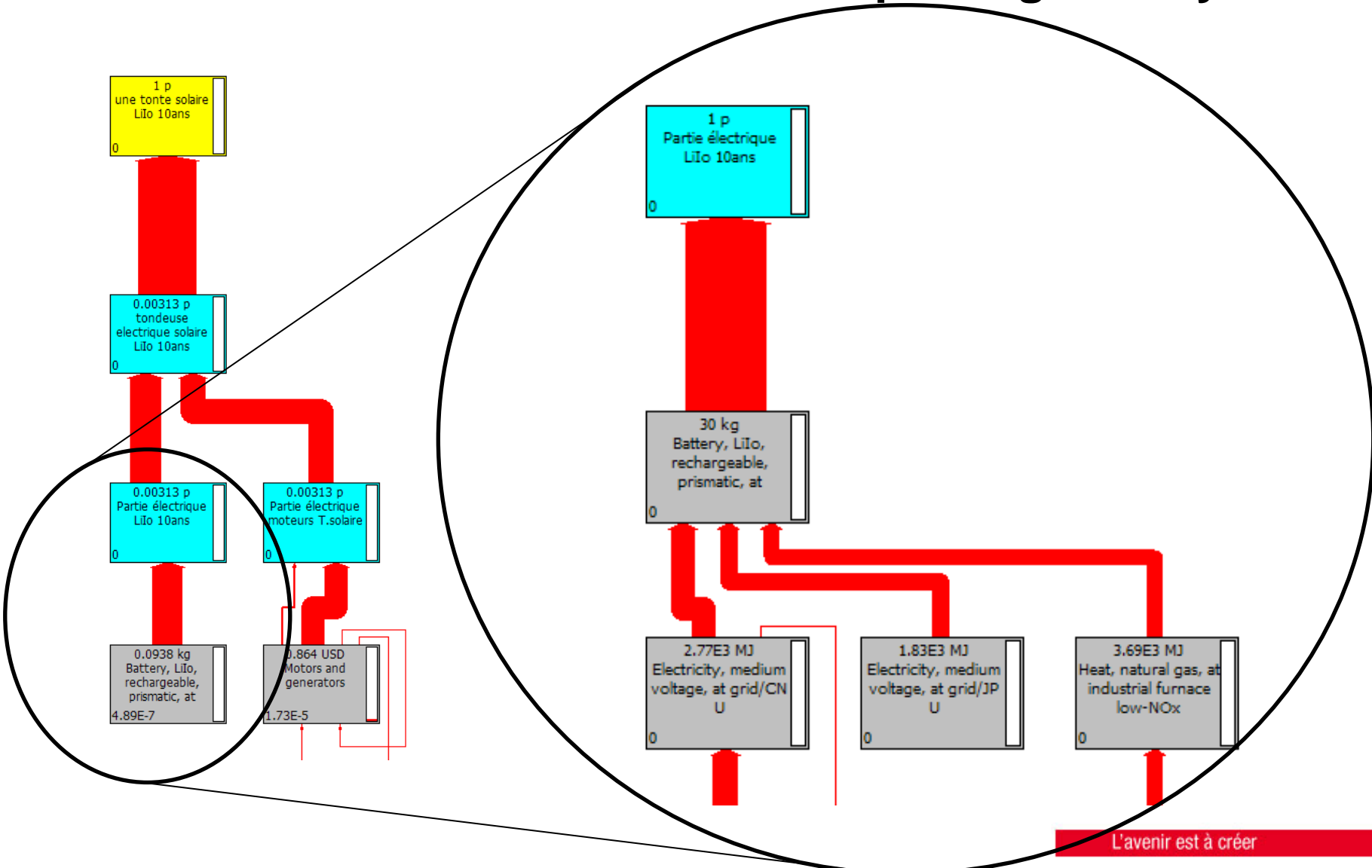
Solar lawn mower comparative LCA score:



Comparaison de 1 p 'une tonte essence', 1 p 'une tonte fils', 1 p 'une tonte solaire Li-Io 10ans' et 1 p 'une tonte solaire Li-Io 20ans', méthode: IMPACT 2002+ V2.05 / IMPACT 2002+ / score unique

L'avenir est à créer

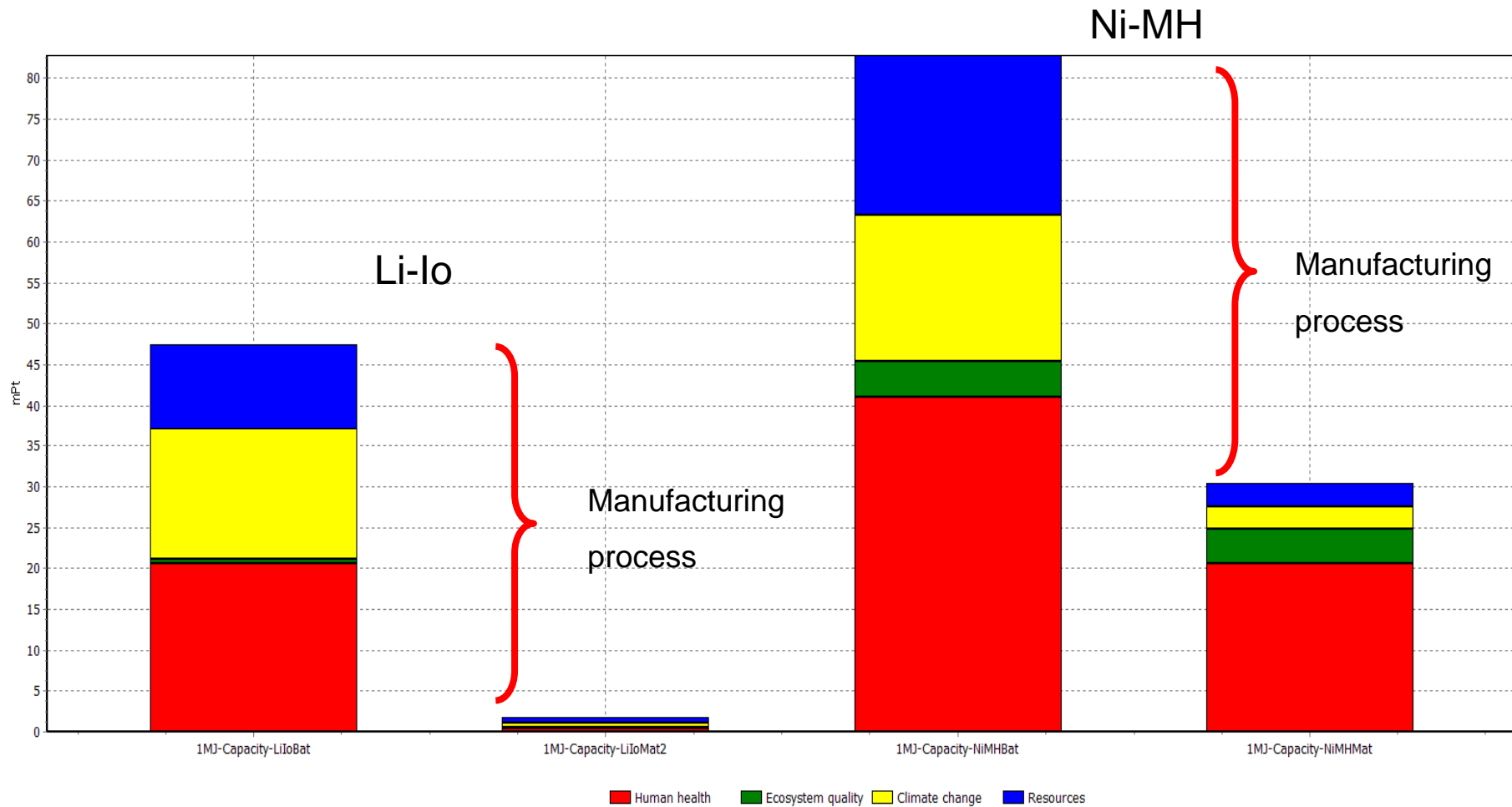
Solar lawn mower – Li-Io batteries impacting heavily:



L'avenir est à créer

Some Investigation on NiMH & Li-Io batteries

Comparison [battery - material only] to
[battery - including manufacturing process]



Comparaison de 1 p '1MJ-Capacity-LiIoBat', 1 p '1MJ-Capacity-LiIoMat2', 1 p '1MJ-Capacity-NiMHBat' et 1 p '1MJ-Capacity-NiMHMat', méthode: IMPACT 2002+ V2.05 / IMPACT 2002+ / score unique

Some observations about batteries

Li-Io (as well as NiMH) batteries manufacturing process need much energy (electricity from China and Japan).

Energetic efficiency ratio :: [manufacturing energy] / [stored energy]

- ECOINVENT document (Li-Io batteries for labtop):
 - E-ratio = 736 [MJ manuf /MJ]
 - E-ratio 2220 [MJ nre /MJ]
- JAPAN - Central Research Institute of Electric Power Industry document (Li-Io batteries for automotive application):
 - E-ratio = 477 [MJ ? /MJ]

Conclusion

- Manufacturing process seems to contribute heavily to environmental impacts.
 - Manufacturing “green” batteries from total live cycle point of view is a great challenge and many improvements have to be done.
 - LCA is a crucial tool to help to this.
 - It is needed to know more about batteries.
 - Data base also need to be fulfilled and updated.
 - Sill lot of work!
-
- **Is it the best answer to energy storage problem from the environmental point of view**

Addendum:

Some questions about batteries

There are many kind of batteries – usually using oxydo-reduction reaction (Pb-PbO, NiCd, NiMH, Li-Io*, Ag-Zn, Ni-NaCl).

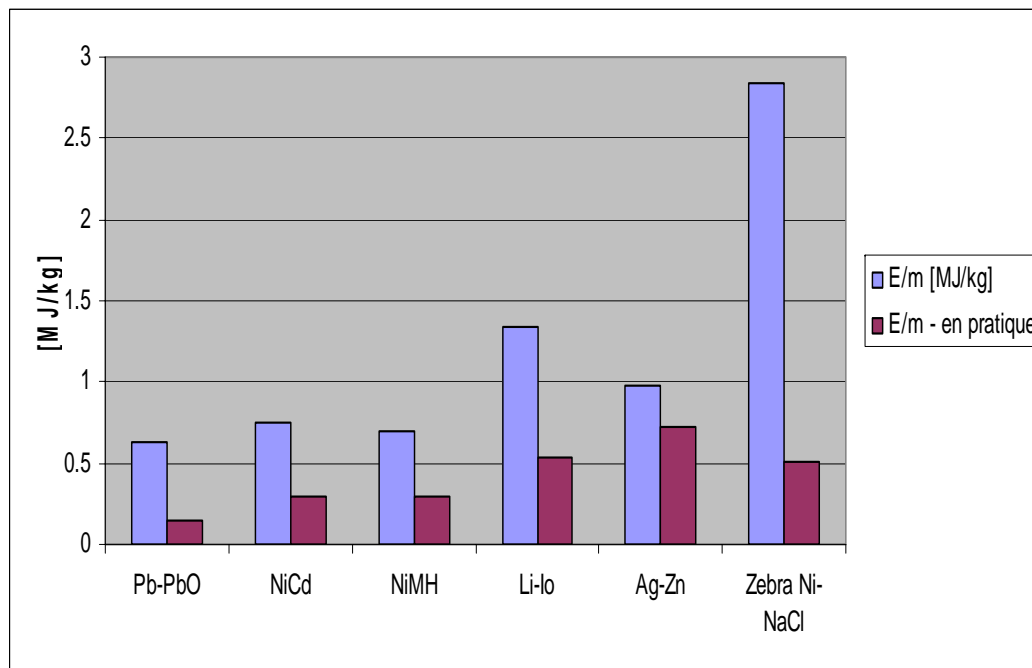
- What is the stored energy dependence from material ?
- What about environmental impact according to material ?

*Li-Io uses Li migration trough membrane

Energy massive density of Pb-PbO, NiCd, NiMH, Li-Io, Ag-Zn, Ni-NaCl batteries

E/m (Energy massive density) :: [mass chemical elements] / [stored energy]

Comparison of theoretical E/m with E/m in practice



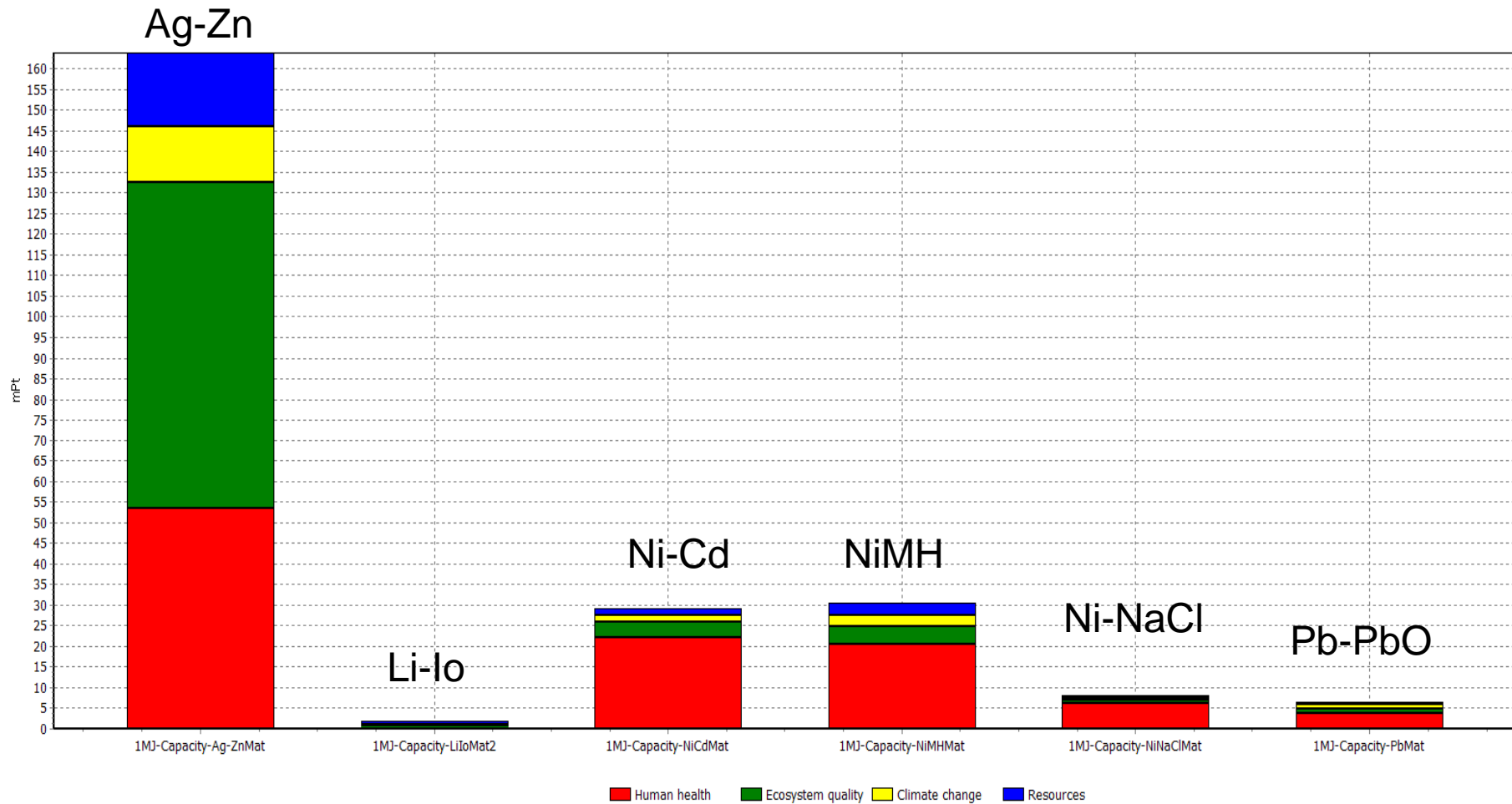
Li-Io, Ag-Zn, Ni-NaCl are the “best in class”.

Difference of “theoretical E/m ” with “ E/m in practice” related to the ratio [active surface] / [supporting structure]

Environmental impact according to material of Pb-PbO, NiCd, NiMH, Li-Io, Ag-Zn, Ni-NaCl batteries

Environmental impact according to material only (no manuf. ; no disposal)

- UF = 1 MJ storage capacity (with practical E/m)



Conclusion about addendum

- Li-Io, Ag-Zn, Ni-NaCl have interesting E/m ratio
 - Ag-Zn already close to theoretical limit E/m ratio
 - Ag-Zn environmental impacts are catastrophic due to Ag
 - Li-Io and Ni-NaCl are interesting field to develop from environmental impacts point of view
-
- But:
 - Manufacturing process of Li-Io should be optimized
 - (Manufacturing process of Ni-NaCl unknown)

Thanks for attention

More information?

- www.hepia.ch
- www.hes-imec.ch



« Apprendre à faire plus avec moins »

Authors:

eric.vittecoq@hesge.ch

jacques.richard@hesge.ch